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DISTANT EKOs

The Kuiper Belt Electronic Newsletter

Edited by: Joel Wm. Parker

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CONTENTS

NEWS & ANNOUNCEMENTS

There were 35 new TNO discoveries announced since the previous issue of the *Distant EKOs* Newsletter:

2002 FW36, 2002 FX36, 2002 GA32, 2002 GB32, 2002 GC32, 2002 GD32, 2002 GE32, 2002 GF32, 2002 GG32, 2002 GH32, 2002 GJ32, 2002 GK32, 2002 GL32, 2002 GM32, 2002 GN32, 2002 GO32, 2002 GP32, 2002 GQ32, 2002 GR32, 2002 GS32, 2002 GT32, 2002 GU32, 2002 GV31, 2002 GV32, 2002 GW31, 2002 GW32, 2002 GX31, 2002 GX32, 2002 GY31, 2002 GZ31, 2002 GA33, 2002 GB33, 2002 GG166, 2002 GH166, 2002 GJ166

and 3 new Centaur/SDO discoveries:

2002 GZ32, 2002 GY32, 2002 FY36

Reclassified objects:
2001 KG76 (TNO → SDO)
2001 KV76 (TNO → SDO)
2002 CX154 (TNO → SDO)
2002 GB32 (TNO → SDO)
2001 KY76 (SDO → TNO)
2001 KN77 (SDO → TNO)
2002 GO9 (SDO → Centaur)

Objects recently assigned numbers:
2001 UR163 = (42301)
2002 CR46 = (42355)
1999 KR16 = (40314)

Current number of TNOs: 562 (and Pluto & Charon, and 7 other TNO binary companions)
Current number of Centaurs/SDOs: 115

PAPERS ACCEPTED TO JOURNALS

Trans-Neptunian Objects: Relics from the Accretion Disk of The Sun

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The Kuiper Belt objects (KBOs) consist of a large number of small, solid bodies in heliocentric orbit beyond Neptune. Discovered as recently as 1992, the KBOs are thought to hold the keys to understanding the origin of the short-period comets. The TNOs are probably best viewed as aged relics of the sun's accretion disk. Dynamical structures in the KBOs provide evidence for processes operative in the earliest days of the solar system, including a phase of planetary migration and a clearing phase, in which substantial mass was lost from the disk. Dust is produced to this day by collisions between KBOs. In its youth, the Kuiper Belt may have compared to the dust rings observed now around such stars as GG Tau and HR 4796A. This review presents the basic physical parameters of the KBOs and makes connections with the disks observed around nearby stars.

To appear in: Annual Reviews of Astronomy and Astrophysics (2002)
Preprints available online at: `http://www.ifa.hawaii.edu/~jewitt/papers/ARAA/araa.ps.gz`

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Trans-Neptunian Objects

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The Trans-Neptunian objects (TNOs) constitute a new class of solar system object that was discovered only recently to exist beyond the orbit of Neptune. About 400 Trans-Neptunian objects have been detected over the past nine years and more than ten new objects are being discovered every month. All of the TNOs known to date fit into three dynamical classes: the classical, the resonant and the scattered objects. The total mass of the TNOs currently orbiting the Sun is estimated from the observed luminosity distribution to be of the order of 10-20% of the Earth's mass. However, theoretical investigations of the formation and evolution of the Trans-Neptunian belt into its currently observed shape suggest that it was much more massive in the past. The physical characterisation of TNOs starts to reveal some of the basic properties of these objects, such as size, shape and rotation and provides a first glance into the diversity of their surfaces. TNOs cover a very diverse range of colours, possibly reflecting different surface compositions. First evidence for the presence of water ice was found in a spectrum of one TNO while others do not show the characteristic absorption bands. The TNOs are now regarded as the likely source of some short-period comets. Owing to giant-planet and collisional perturbations, some TNOs may evolve into Centaurs, i.e. objects orbiting the Sun in the region between Jupiter and Neptune, which are further perturbed to become Jupiter-family short-period comets. Together with smaller debris generated by collisional shattering, the TNOs might represent a belt that has evolved from a more massive circumstellar disc into its present structure.

Published in: The Astronomy and Astrophysics Review, 11, 1 (2002)
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Evidence for an Extended Scattered Disk

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By telescopic tracking, we have established that the trans-Neptunian object (TNO) 2000 CR_{105} has a semimajor axis of 220±1 AU and perihelion distance of 44.14±0.02 AU, beyond the domain which has heretofore been associated with the 'scattered disk' of Kuiper Belt objects interacting via gravitational encounters with Neptune. We have also firmly established that the TNO 1999 TL_8 has a high perihelion (of 40.08±0.02 AU). These objects, and two other recent discoveries which appear to have perihelia outside 40 AU, have probably been placed on these orbits by a gravitational interaction which is *not* strong gravitational scattering off of any of the giant planets on their current orbits. Their existence may thus have profound cosmogonic implications for our understanding of the formation of the outer Solar System. We discuss some viable scenarios which could have produced these objects, including long-term diffusive chaos and scattering off of other massive bodies in the outer Solar System.

This discovery implies that there must be a large population of TNOs in an 'extended scattered disk' with perihelia above the previously-suggested 38 AU boundary. The total population is difficult to estimate due to the ease with which such objects would have been lost. This illustrates the great value of frequent and well time-sampled recovery observations of trans-Neptunian objects within their discovery opposition.

Published in: Icarus 157, 269 (2002 June)

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Stochastic Effects in Planet Migration and Orbital Distribution of the Kuiper Belt

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Assuming the Jovian planets experienced smooth orbital migrations, Malhotra (1993, 1995) successfully explained some important features of the Kuiper belt by the mechanism of resonance capture. But really the migration should be stochastic. In this paper we numerically simulate numerous test particles' orbital evolutions under such stochastic planet migrations. The main results are as follows. Given the proper parameters, the concentration of objects in the 3:2 resonance is distinct, while very few objects enter the 2:1 resonance, and consequently, the orbital distribution of Kuiper belt objects match the observational data very well. The stochastic effects excite the orbital eccentricities and inclinations of objects in the non-resonant regions. The introduction of stochastic effects also gives possible explanations of the mass depletion, and of the sources of the classical and scattered Kuiper belt objects.

To appear in: Monthly Notices of the Royal Astronomical Society

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Long-Term Dynamics and the Orbital Inclinations of the Classical Kuiper Belt Objects

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We numerically integrated the orbits of 1458 particles in the region of the classical Kuiper Belt (41 AU $\leq a \leq$ 47 AU) to explore the role of dynamical instabilities in sculpting the inclination distribution of the classical Kuiper Belt Objects (KBOs). We find that the selective removal of low-inclination objects by overlapping secular resonances (ν_{17} and ν_{18}) acts to raise the mean inclination of the surviving population of particles over 4 billion years of interactions with Jupiter, Saturn, Uranus and Neptune, though these long-term dynamical effects do not themselves appear to explain the discovery of KBOs with inclinations near 30°. Our integrations also imply that after 3 billion years of interaction with the massive planets, high inclination KBOs more efficiently supply Neptune-encountering objects, the likely progenitors of short-period comets, Centaurs, and scattered KBOs. The secular resonances at low inclinations may indirectly cause this effect by weeding out objects unprotected by mean motion resonances during the first 3 billion years.

To appear in: The Astronomical Journal

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and `http://arXiv.org/abs/astro-ph/0206260`

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A Collisional Family in the Classical Kuiper Belt

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The dynamical evolution of Classical Kuiper Belt Objects (CKBOs) divides into two parts, according to the secular theory of test particle orbits. The first part is a forced oscillation driven by the planets, while the second part is a free oscillation whose amplitude is determined by the initial orbit of the test particle. We extract the free orbital inclinations and free orbital eccentricities from the osculating elements of 125 known CKBOs. The free inclinations of 32 CKBOs strongly cluster about 2° at orbital semi-major axes between 44 and 45 AU. We propose that these objects comprise a collisional family, the first so identified in the Kuiper Belt. Members of this family are plausibly the fragments of an ancient parent body having a minimum diameter of ∼800 km. This body was disrupted upon colliding with a comparably sized object, and generated ejecta having similar free inclinations. Our candidate family is dynamically akin to a sub-family of Koronis asteroids located at semi-major axes less than 2.91 AU; both families exhibit a wider range in free eccentricity than in free inclination, implying that the relative velocity between parent and projectile prior to impact lay mostly in the invariable plane of the solar system. We urge more discoveries of new CKBOs to test the reality of our candidate family and physical studies of candidate family members to probe the heretofore unseen interior of a massive, primitive planetesimal.

To appear in: The Astrophysical Journal Letters

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Implications Regarding the Energetics of the Collisional Formation of Kuiper Belt Satellites

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Recently, it has been discovered that at least 1% of Kuiper Belt Objects (KBOs) are accompanied by large satellites. Here we examine the energetics of KBO satellite formation via collisions, finding collisions require a dynamically excited Kuiper Belt. Further, even under optimistic assumptions (including perfect accretion of the satellites), we find that collisional processes cannot make KBO satellites at the observed frequency of occurrence unless KBO projectiles large enough to generate the observed satellites were ∼40 times more numerous in the ancient past, resulting in an increased collision rate with sufficiently large projectiles, or unless the fraction of impact energy estimated to be imparted to ejecta is of order unity. Neither alternative is very palatable. However, an easier to accept alternative also exists: KBO primary and/or KBO satellite surface albedos presently be underestimated by making the canonical assumption of 4% surface albedos; specifically, surface albedos of KBO primaries and/or their satellites could be in the neighborhood of 15% (or higher). This would reduce KBO primary and/or satellite sizes and masses, thereby in turn reducing the required size of the impacting projectiles required to generate KBO satellites, which in turn would increase the impact rate with sufficiently large projectiles to values in line with the observed fraction of KBOs with large satellites. This proposition is expected to be easily testable with by SIRTF and by other means in the next 2 to 3 years.

To appear in: The Astronomical Journal
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Evidence for a Collisional Mechanism Affecting Kuiper Belt Object Colors

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The Kuiper Belt (KB) region of the solar system, stretching from 30 to at least 50 AU, contains Pluto-Charon, some ∼105 Kuiper Belt Objects (KBOs) larger than 100 km in diameter, and myriad smaller bodies produced by collisions among KBOs (Farinella, Davis, & Stern 2000). The most notable physical attribute of the KBOs discovered to date is their reflectance color diversity, ranging from gray (i.e., neutral) to very red (Tegler & Romanishin 2000). We report here evidence for a statistical correlation between the colors of KBOs and the mean random impact speed that these objects experience, lending evidence to suggestions some years ago by modelers (Jewitt & Luu 1996) that a competition between collisional resurfacing and radiation reddening may contribute to the color diversity of KBOs.

To appear in: The Astronomical Journal
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The Color Distribution in the Edgeworth-Kuiper Belt

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We have started since 1997 the Meudon Multicolor Survey of Outer Solar System Objects with the aim of collecting a large and homogeneous set of color data for Trans-Neptunian and Centaurs objects. We present here our latest $B-V$, $V-R$ and $R-I$ colors measurements obtained with the CFH12K mosaic camera of the 3.6m Canada-France-Hawaii Telescope (CFHT). With the colors of 30 objects reported in this work, we have a combined sample of 52 B-R color measurements for 8 Centaurs, 22 Classicals, 13 Plutinos, 8 Scattered objects and 1 object with unidentified dynamical class. This dataset is the largest single and homogeneous published dataset to date, and is large enough to search for compositional structures, interrelations between dynamical classes of objects and correlations with physical and orbital parameters. The color-color diagrams show that all the classes of objects share the same wide color diversity. No significant correlations are seen for the whole population of TNOs and Centaurs, as well as for individual sub-populations, except for the Classicals. Indeed, we found a significant and strong correlation of the colors of Classicals with inclination, eccentricity and perihelion, but nothing with semi-major axis and absolute magnitude. Most of these results are common to other previous works and do not seem to be due to sampling bias. Moreover, a strong correlation with mean excitation velocity $[(V_k(e^2+i^2)^{1/2}]$ points toward a space weathering/impact origin for the color diversity. However, thorough modeling of the collisional/dynamical environment in the Edgeworth-Kuiper belt needs to be done in order to confirm this scenario. We found also that the Classical TNOs consist in the superposition of two distinct populations: the dynamically Cold Classical TNOs (red colors, low i, small sizes) and the dynamically Hot Classical TNOs (diverse colors, moderate and high i, larger sizes). Furthermore, the latter population displays a strong correlation between color and mean excitation velocity. The dynamically Cold Classical TNOs may be primordial while the dynamically Hot Classical TNOs, whose surfaces colors may be the result of space weathering/impact processes, have possibly been injected from the inner regions of the disk. Our specific observation strategy to repeat color measurements with no rotation artifacts have permitted us to highlight a few objects suspected to have true compositional and/or texture variation on their surfaces. These TNOs are 1998 HK_{151}, 1999 DF_9, 1999 OY_3, 2000 GP_{183}, 2000 OK_{67}, and 2001 KA_{77} and should be prime targets for further observations in order to study and confirm the color variation with the rotation. Finally, our survey has also highlighted some peculiar objects such as 1998 SN_{165} whose colors and dynamical properties put this object in a new dynamical class distinct from the Classicals, its previously assigned dynamical class.

To appear in: The Astronomical Journal

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Coordinated Thermal and Optical Observations of Trans-Neptunian Object (20000) Varuna from Sierra Nevada

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We report on coordinated thermal and optical measurements of the trans-Neptunian object (20000) Varuna obtained in January-February 2002, respectively from the IRAM 30-m and IAA 1.5-m telescopes. The optical data show a lightcurve with a period of 3.176±0.010 hr, a mean V magnitude of 20.37±0.08 and a 0.42±0.01 magnitude amplitude. They also tentatively indicate that the lightcurve is asymmetric and double-peaked. The thermal observations indicate a 1.12±0.41 mJy flux, averaged over the object's rotation. Combining the two datasets, we infer that Varuna has a mean 1060^{+180}_{-220} km diameter and a mean $0.038^{+0.022}_{-0.010}$ V geometric albedo, in general agreement with an earlier determination using the same technique.

To appear in: Astronomy & Astrophysics

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or on the web at `http://arxiv.org/abs/astro-ph/0206486/`

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Visible-IR Colors and Lightcurve Analysis of Two Bright TNOs: 1999 TC_{36} and 1998 SN_{165}

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We report on observations of two bright Trans-Neptunian Objects (TNOs) — 1999 TC_{36} and 1998 SN_{165} — during two observational campaigns, as part of the Meudon Multicolor Survey of Outer Solar System Objects. $V - J$ color was measured for 1999 TC_{36} ($V - J = 2.34 \pm 0.18$), which combined with previous measured colors in the visible, indicate a red reflectivity spectrum at all wavelengths. Photometric V-band lightcurves were taken for both objects over a time span of around 8 hours. We have determined a possible rotational period of $P = 10.1 \pm 0.8$ h for 1998 SN_{165}, making it the seventh TNO with an estimated period. From its lightcurve variation of $\Delta m = 0.151^{+0.022}_{-0.030}$, we have inferred an asymmetry ratio of $a/b \geq 1.148^{+0.024}_{-0.031}$. For 1999 TC_{36}, we did not detect any rotational period or periodic signal variation within the uncertainties, but the analysis of its lightcurve hints to a slight systematic magnitude decrease.

To appear in: New Astronomy 7, 359 (2002 August)

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Time-Resolved Photometry of Kuiper Belt Objects: Rotations, Shapes and Phase Functions

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We present a systematic investigation of the rotational lightcurves of trans-Neptunian objects based on extensive optical data from Mauna Kea. Four of 13 objects (corresponding to 31%) in our sample ((33128) 1998 BU_{48}, 2000 GN_{171}, (20000) Varuna and 1999 KR_{16}) were found to exhibit lightcurves with peak-to-peak range ≥ 0.15 magnitude. In a larger sample obtained by combining our data with reliably determined lightcurves from the literature, 7 of 22 objects (32%) display significant (≥ 0.15 magnitude range) lightcurves. About 23% of the sampled objects have lightcurve ranges ≥ 0.4 magnitudes. Curiously, the objects are very large ($\gtrsim 250$ km diameter, assuming an albedo of 0.04) and, in the absence of rotation, should be near spherical due to self compression. We propose that the large amplitude, short period objects are rotationally distorted, low density rubble piles. Statistically, the trans-Neptunian objects are less spherical than their main-belt asteroid counterparts, indicating a higher specific angular momentum perhaps resulting from the formation epoch. In addition to the rotational lightcurves, we measured phase darkening for 7 Kuiper Belt objects in the 0 to 2 degree phase angle range. Unlike Pluto, the measured values show steep slopes and moderate opposition surge indicating backscatter from low albedo porous surface materials.

To appear in: The Astronomical Journal
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New Activity of Chiron: Results from 5 Years of Photometric Monitoring

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The results of photometric observations of Centaur object Chiron carried out at the Observatório do Pico–dos–Dias (OPD-Brazil), the Estación Astrofísica de Bosque Alegre (EABA-Argentina) and Complejo Astronómico El Leoncito (CASLEO-Argentina) from 1997 up to 2001 are presented here. The analysis of the photometric data shows that the brightness of Chiron reached a minimum value in 1999 and began increasing again in 2000. The absolute magnitude, H_V, varied from 7.26 in June 1999 to 5.78 in April 2001. The data tend to indicate that Chiron is starting a new outburst of activity which is compatible with a sporadic cometary behavior not related to heliocentric distance.

To appear in: Icarus
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Lightcurves of Centaurs 2000 QC_{243} and 2001 PT_{13}

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We present CCD photometric observations of Centaurs 2000 QC_{243} and 2001 PT_{13}. For 2000 QC_{243}, a large amplitude period is found at 4.57 ± 0.05 h, which likely corresponds to half the rotation period of the body, or coincides with the full rotation period, depending on whether the variability is induced by an irregular shape or by albedo features. The apparent double-peaked lightcurve favors the first interpretation. The large amplitude of the oscillations imply a very irregular shape for this object or a large albedo asymmetry between the two hemispheres. For 2001 PT_{13}, a clear period of 4.15 ± 0.05 h was detected, with an amplitude of 0.16 mag. Since 4.15 h is close to the breakup limit for typical cometary densities and tensile strengths, 8.3 h appears to be a more likely rotation period.

Published in: Astronomy & Astrophysics, 388, 661 (2002 June)

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or on the web at `http://www.iaa.csic.es/~ortiz/papers/aa02.html`

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Visible and Near-infrared Spectroscopy of the Centaur 32532 (2001 PT13). ESO Large Program on TNOs and Centaurs: First Spectroscopy Results

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We present photometric and spectroscopic data obtained through visible and near-infrared observations of the Centaur 32532 (2001 PT13) performed with FORS1 and ISAAC at the Very Large Telescope (VLT-ESO) within the framework of a large ESO program on the Trans-Neptunian objects (TNOs) and Centaurs. The results show evidence for a difference in the near-infrared spectral behaviour obtained during two observations carried out one month apart. In one spectrum there is the possible presence of signatures of water ice in small amounts. Two models have been proposed to interpret the surface composition of this Centaur.

To appear in: Astronomy & Astrophysics

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PAPERS RECENTLY SUBMITTED TO JOURNALS

The Rotational and Physical Properties of the Centaur (32532) 2001 PT_{13}

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Submitted to: Icarus

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OTHER PAPERS OF INTEREST

The Mass Disruption of Oort Cloud Comets

Harold F. Levison[1], Alessandro Morbidelli[2], Luke Dones[1], Robert Jedicke[3], Paul A. Wiegert, and William F. Bottke, Jr.[1]

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Published in: Science, 296, 2212 (2002 June 21)

For preprints, contact hal@gort.boulder.swri.edu

or on the web at http://www.boulder.swri.edu/~hal/disrupt.html

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Radio Continuum Observations of Comet C/1999 S4 (LINEAR) Before, During, and After Break-Up of its Nucleus

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To appear in: Astronomy & Astrophysics

For preprints, contact wja@mpifr-bonn.mpg.de

CONFERENCE CONTRIBUTIONS

Migration of Matter from the Edgeworth-Kuiper and Main Asteroid Belts to the Earth

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[2] NASA/GSFC, Greenbelt, MD, USA

To appear in: Proceedings of IAU Colloquium No 181 and COSPAR Colloquium No. 11: "Dust in the Solar System and Other Planetary Systems"

For preprints, contact siipatov@hotmail.com

or on the web at http://arXiv.org/abs/astro-ph/0205250

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Formation and Migration of Trans-Neptunian Objects

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To appear in: Celestial Mechanics — 2002: Results and Prospect

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or on the web at http://arXiv.org/abs/astro-ph/0205307

CONFERENCE INFORMATION

Finding the New Horizons KBO Flyby Target(s)

2002 October 6
Workshop at the DPS meeting
Birmingham, Alabama, USA

Workshop Contact: John Spencer, Lowell Observatory
New Horizons Science Team
spencer@lowell.edu
(720) 240-0115 (until 2002/10/31)

The New Horizons Pluto/Kuiper Belt mission is currently in development. Mission plans include a flyby of one or more Kuiper Belt Objects after (or conceivably before) the Pluto flyby, in the 2015-2025 time frame.

Finding the KBO flyby candidate will be a big job, because already the search area is within the Milky Way, near the galactic center, and will remain there till shortly before the Pluto flyby. We will need to find efficient ways to conduct near-complete searches for mag. 26-27 objects in very dense star fields.

We will hold a 1-day workshop on the subject of finding the New Horizons KBO targets the day before the DPS meeting, on Sunday October 6th. Please let me know if you are interested in attending or speaking at the workshop, or otherwise helping to plan and execute the search effort.

The *Distant EKOs* Newsletter is dedicated to provide researchers with easy and rapid access to current work regarding the Kuiper belt (observational and theoretical studies), directly related objects (e.g., Pluto, Centaurs), and other areas of study when explicitly applied to the Kuiper belt.

We accept submissions for the following sections:
⋆ Abstracts of accepted papers
⋆ Titles of submitted (but not yet accepted) papers and conference articles
⋆ Thesis abstracts
⋆ Short articles, announcements, or editorials
⋆ Status reports of on-going programs
⋆ Requests for collaboration or observing coordination
⋆ Table of contents/outlines of books
⋆ Announcements for conferences
⋆ Job advertisements
⋆ General news items deemed of interest to the Kuiper belt community

A LaTeX template for submissions is appended to each issue of the newsletter, and is sent out regularly to the e-mail distribution list. Please use that template, and send your submission to:

`ekonews@boulder.swri.edu`

The *Distant EKOs* Newsletter is available on the World Wide Web at:

`http://www.boulder.swri.edu/ekonews`

Recent and back issues of the newsletter are archived there in various formats. The web pages also contain other related information and links.

Distant EKOs is not a refereed publication, but is a tool for furthering communication among people interested in Kuiper belt research. Publication or listing of an article in the newsletter or the web page does not constitute an endorsement of the article's results or imply validity of its contents. When referencing an article, please reference the original source; *Distant EKOs* is not a substitute for peer-reviewed journals.

Moving ... ??

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